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## (54) LOW-MELTING OPTICAL GLASS

## (57)Abstract:

**PURPOSE:** To obtain the subject glass having high refractive index and high dispersion characteristics, enabling itself to be press molded at relatively low temperatures by specifying the amounts of the respective components in P2O5-Na2O-Nb2O5-WO3-based or P2O5-B2O3-Li2O-Na2O-Nb2O5-based phosphate glass.

**CONSTITUTION:** The 1st embodiment: a glass feedstock composition comprising 2-29wt.% of P2O5, 2-25wt.% of Na2O, 4-22wt.% of Nb2O5, 20-52wt.% of WO3 and a specified weight range of any other desired component is melted by heating at 1000-1200° C, clarified, homogenized by agitation, cast and then annealed, thus gives the objective optical glass having the following characteristics such as refractive index of 1.70-1.86, dispersive power of 35-21 and glass yield point of ≤570° C. The 2nd embodiment: a glass feedstock composition comprising 12-32wt.% of P2O5, 0.5-16wt.% of B2O3, 0.3-6wt.% of Li2O, 2-22wt.% of Na2O, 8-52wt.% of Nb2O5 and a specified weight range of any other desired component is subjected to the same processes as those mentioned above to obtain the objective optical glass having the following characteristics such as refractive index of 1.69-1.83, dispersive power of 32-21 and glass yield point of ≤570° C.

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(54)【発明の名称】 低融点光学ガラス

(57)【要約】

【目的】 より高屈折率及び高分散特性を有するとともに、低い温度でガラスが失透せずに軟化してプレス成形することが可能であり、かつ液相温度が低く安定性に優れた光学ガラスの提供。

【構成】 重量%で表示して、P<sub>2</sub>O<sub>5</sub>を2~29%、Na<sub>2</sub>Oを2~25%、Nb<sub>2</sub>O<sub>5</sub>を4%以上22%未満、WO<sub>3</sub>を20~52%含むことを特徴とする低融点光学ガラス。このガラスは、屈折率が1.70~1.86、分散率が21~35、ガラス屈伏点が570℃以下である。重量%で表示して、P<sub>2</sub>O<sub>5</sub>を12~32%、B<sub>2</sub>O<sub>3</sub>を0.5~16%、Li<sub>2</sub>Oを0.3~6%、Na<sub>2</sub>Oを2~22%、Nb<sub>2</sub>O<sub>5</sub>を8~52%含むことを特徴とする低融点光学ガラス。このガラスは、屈折率が1.69~1.83、分散率が21~32、ガラス屈伏点が570℃以下である。

## 【特許請求の範囲】

【請求項1】 重量%で表示して、 $P_2O_5$ を2~29%、 $Na_2O$ を2~25%、 $Nb_2O_5$ を4%以上22%未満、 $WO_3$ を20~52%含むことを特徴とする低融点光学ガラス。

【請求項2】 屈折率 $n_d$ が1.70~1.86の範囲であり、分散率 $r_d$ が35~21の範囲であり、かつガラス屈伏点( $T_s$ )が570℃以下である請求項1に記載の低融点光学ガラス。

【請求項3】 重量%で表示して、 $P_2O_5$ を12~32%、 $B_2O_3$ を0.5~16%、 $Li_2O$ を0.3~6%、 $Na_2O$ を2~22%、 $Nb_2O_5$ を8~52%含むことを特徴とする低融点光学ガラス。

【請求項4】 屈折率 $n_d$ が1.69~1.83の範囲であり、分散率 $r_d$ が32~21の範囲であり、かつガラス屈伏点 $T_s$ が570℃以下である請求項3に記載の低融点光学ガラス。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は、低温度でプレスすることができ、非球面精密プレス用として有用な低融点光学ガラスに関する。

## 【0002】

【従来の技術】従来の高屈折率、高分散を示す光学ガラスとしては、例えば $P_2O_5-Nb_2O_5$ -アルカリ金属酸化物系ガラス(特公昭56-40094号公報)がある。さらに、 $SiO_2-TiO_2-Nb_2O_5$ -アルカリ金属酸化物系ガラス(特開昭63-265840号公報)も高屈折率、高分散を示す光学ガラスである。しかし、これらのガラスの屈伏温度( $T_s$ )は600℃以上と高い。通常、精密プレス成形は、屈伏温度( $T_s$ )より30℃~50℃高い温度で行なわれる。よって、上記のガラスを精密プレス成形する場合、プレス温度は650℃~700℃の範囲となる。ところが、このような高温でプレスを繰り返し行うと、型材の劣化が著しく、プレス開始後、比較的短時間の内に精密なガラス面が得られなくなってしまう。そこで、精密なガラス面を得るために型の交換を頻繁に行う必要があるが、それでは精密レンズを量産することは非常に困難である。

【0003】このような観点から、精密プレスレンズ製造における型の寿命を延長するための1つの策として、屈伏温度( $T_s$ )の低いガラスを用いることが挙げられる。例えば、特開平1-308843号公報には、高屈折率、高分散を示す低融点光学ガラスである $SiO_2-PbO$ -アルカリ金属酸化物系のガラスが開示されている。さらに、特開平5-51233号公報には、高屈折率、高分散を示す低融点光学ガラスである $SiO_2-GeO_2-TiO_2-Nb_2O_5$ -アルカリ金属酸化物系のガラスが開示されている。

## 【0004】

【発明が解決しようとする課題】しかしながら、これらの特許公報に記載のガラスにはいくつかの問題点があった。例えば、特開平1-308843号記載のガラスは多量の酸化鉛を含んでいる。一方、ガラスのプレスは、通常、型の酸化を防ぐために還元性雰囲気で行われる。そのため、上記酸化鉛含有ガラスの場合、ガラス中の酸化鉛が還元性雰囲気中で還元されて金属鉛が表面に析出する。析出した金属鉛は、型表面に付着して、ガラスをプレスする際にガラス表面に凸凹をつくり、面精度が悪くなってしまう。それに対して特開平5-51233号に記載のガラスは、ガラス成分中に $PbO$ を含まない低融点光学ガラスである。しかし、このガラスは液相温度が高く、軟化温度付近での失透傾向も強い。そのため、ガラスブリフォームを昇温して軟化させ、精密プレス成形をすることは困難であり、プレスレンズの製造には適さない。

【0005】そこで本発明の目的は、高屈折率及び高分散特性を有するとともに、低い温度でガラスが失透せずに軟化してプレス成形することが可能であり、かつ液相温度が低く安定性に優れた光学ガラスを提供することにある。

## 【0006】

【課題を解決するための手段】本発明の第1の態様の光学ガラスは、重量%で表示して、 $P_2O_5$ を2~29%、 $Na_2O$ を2~25%、 $Nb_2O_5$ を4%以上22%未満、 $WO_3$ を20~52%含むことを特徴とする低融点光学ガラスに関する。

【0007】本発明の第2の態様の光学ガラスは、重量%で表示して、 $P_2O_5$ を12~32%、 $B_2O_3$ を0.5~16%、 $Li_2O$ を0.3~6%、 $Na_2O$ を2~22%、 $Nb_2O_5$ を8~52%含むことを特徴とする低融点光学ガラスに関する。

【0008】以下、まず、本発明の第1の態様の光学ガラスについて、各成分およびその含量の限定理由を説明する。 $P_2O_5$ は燐酸塩ガラスにおいてガラス形成成分として欠かせない成分である。燐酸塩ガラスは珪酸塩ガラスと比べて低い温度でガラスを溶融することができ、可視域の透過率が高いという特徴をもつ。また同じガラス形成酸化物成分である $SiO_2$ や $B_2O_3$ に比べて $P_2O_5$ は高分散側に位置する成分のため、アッペ数3.5以下の光学特性を得るには、 $P_2O_5$ は少なくとも2%は必要である。逆に29%を越えると失透性が強くなり、安定なガラスが得られなくなる。そのため、 $P_2O_5$ の含量は2~29%に限定される。好みい $P_2O_5$ の含量は4~26%の範囲である。

【0009】 $Na_2O$ はガラスの屈伏温度( $T_s$ )を下げ、液相温度を下げる成分として欠かせない成分である。またガラスの粘性を下げることができるので低温で溶解が可能となり、白金るつぼの浸食による着色を抑えることができる。 $Na_2O$ が2%未満では失透性が強く

上記の効果が得られない。また25%を超えると、耐失透性、化学的耐久性が悪くなる。従ってNa<sub>2</sub>Oの含量は2~25%に限定され、好ましくは4~22%である。

[0010] Nb<sub>2</sub>O<sub>5</sub>は、目的とする高屈折率・高分散特性を得るために不可欠な成分であり、また耐久性を上げる効果のある成分でもある。Nb<sub>2</sub>O<sub>5</sub>が4%未満であると目的とする高屈折率・高分散特性が得られなくなり、22%以上では耐失透性が悪くなり、ガラスの屈伏点(T<sub>s</sub>)が上昇する。このためNb<sub>2</sub>O<sub>5</sub>は4%以上22%未満に限定される。好ましいNb<sub>2</sub>O<sub>5</sub>の含量は6~21.5%である。

[0011] WO<sub>3</sub>は目的とする高屈折率・高分散特性を得るために不可欠な成分であり、またガラスの屈伏点(T<sub>s</sub>)を下げるのに非常に有効な成分である。WO<sub>3</sub>が20%未満であると目的とする高屈折率・高分散特性が得られなくなり、ガラスの屈伏点も上昇する。また5.2%を超えると耐失透性が悪くなり、かつガラスが強く着色することになる。このためWO<sub>3</sub>は20~52%に限定される。好ましいWO<sub>3</sub>の含量は23~49%である。

[0012] 本発明の第1の態様の低融点光学ガラスは、後述の実施例からも明らかなように高屈折率で高分散特性を有し、かつ低融点特性を有している。例えば屈折率は1.70~1.86の範囲にあり、アッペ数は3.5~2.1の範囲でガラス屈伏点(T<sub>s</sub>)は570℃以下の範囲である。また液相温度(L·T)を下げることができ、かつガラス塊をプレスする際のガラス軟化点での失透性も従来品よりも優れている。

[0013] 本発明の第1の態様の低融点光学ガラスは、前記成分以外に任意成分として更に、B<sub>2</sub>O<sub>3</sub>、GeO<sub>2</sub>、Li<sub>2</sub>O、K<sub>2</sub>O、Cs<sub>2</sub>O、MgO、CaO、SrO、BaO、ZnO、TiO<sub>2</sub>、Ta<sub>2</sub>O<sub>5</sub>、As<sub>2</sub>O<sub>3</sub>、Sb<sub>2</sub>O<sub>3</sub>等の成分を含むことができる。これら任意成分の含量は、重量%で表示して、B<sub>2</sub>O<sub>3</sub>が0~15%、GeO<sub>2</sub>が0~27%、Li<sub>2</sub>Oが0~4%、K<sub>2</sub>Oが0~15%、Cs<sub>2</sub>Oが0~5%、MgOが0~5%、CaOが0~5%、SrOが0~5%、BaOが0~15%、ZnOが0~7%、TiO<sub>2</sub>が0~16%、Ta<sub>2</sub>O<sub>5</sub>が0~7%、As<sub>2</sub>O<sub>3</sub>が0~2%、Sb<sub>2</sub>O<sub>3</sub>が0~2%の範囲である。以下にその理由を説明する。

[0014] B<sub>2</sub>O<sub>3</sub>及びGeO<sub>2</sub>は、ガラスの安定性を上げる効果が非常に大きな成分である。しかし、B<sub>2</sub>O<sub>3</sub>は15%を超えると、GeO<sub>2</sub>は27%を超えると、目的とする高屈折率・高分散特性が得られなくなり、またガラスの屈伏点も上昇する。そのためB<sub>2</sub>O<sub>3</sub>の含量は0~15%の範囲に、GeO<sub>2</sub>は0~27%の範囲に限定される。好ましくは、B<sub>2</sub>O<sub>3</sub>は0~13%の範囲であり、GeO<sub>2</sub>は0~25%の範囲である。

[0015] Li<sub>2</sub>O、K<sub>2</sub>O及びCs<sub>2</sub>Oは、ガラスの屈伏温度(T<sub>s</sub>)を下げる効果が非常に大きな成分である。しかし、Li<sub>2</sub>Oは4%を超え、K<sub>2</sub>Oは15%を超え、Cs<sub>2</sub>Oは5%を超えると、それぞれ耐失透性、化学的耐久性が悪化する。そのためLi<sub>2</sub>Oは0~4%の範囲、K<sub>2</sub>Oは0~15%の範囲、Cs<sub>2</sub>Oは0~5%の範囲に限定される。好ましくは、Li<sub>2</sub>Oは0~2%の範囲、K<sub>2</sub>Oは0~13%の範囲、Cs<sub>2</sub>Oは0~3%の範囲である。

[0016] アルカリ土類金属酸化物であるMgO、CaO、SrO及びBaOはガラスの液相温度を下げ、安定性を増す効果が大きな成分である。しかし、MgOは5%を超えると、CaOは5%を超えると、SrOは5%を超える、BaOは15%を超えると、目的とする高屈折率・高分散特性が得られず、かつ耐失透性が悪くなる。このためMgO、CaO及びSrOの含量は、それぞれ0~5%の範囲に限定され、BaOは0~15%の範囲に限定される。好ましくは、MgO、CaO及びSrOはそれぞれ0~3%の範囲であり、BaOは0~13%の範囲である。

[0017] TiO<sub>2</sub>は高屈折率・高分散特性を得る効果が大きい成分である。しかし、16%を超えると耐失透性が悪くなり、ガラスの屈伏点が上昇し、強く着色することがある。そのため、TiO<sub>2</sub>の含量は、0~16%の範囲である。

[0018] ZnO及びTa<sub>2</sub>O<sub>5</sub>は、耐失透性を損なわずに少量添加により屈折率の調整をすることが可能である。しかし、それぞれ7%を超えると耐失透性が悪くなる。そのため、ZnO及びTa<sub>2</sub>O<sub>5</sub>の含量は、いずれも0~7%の範囲に限定され、好ましくは0~5%の範囲である。

[0019] As<sub>2</sub>O<sub>3</sub>及びSb<sub>2</sub>O<sub>3</sub>は消色剤および滑溜剤として有効である。しかし、いずれも2%を超えて添加すると耐失透性を悪くする。そのため、As<sub>2</sub>O<sub>3</sub>及びSb<sub>2</sub>O<sub>3</sub>の含量は、それぞれ0~2%の範囲に限定される。尚、本発明の第1の態様の光学ガラスは、本発明の目的を損なわない範囲で、上記の成分以外の成分を含有することもできる。

[0020] 次に、本発明の第2の態様の光学ガラスについて、各成分およびその含量の限定理由を説明する。P<sub>2</sub>O<sub>5</sub>は燐酸塩ガラスにおいて、ガラス形成成分として欠かせない成分である。燐酸塩ガラスは珪酸塩ガラスと比べて低い温度でガラスを溶融することができ、可視域の透過率が高いという特徴をもつ。また同じガラス形成酸化物成分である、SiO<sub>2</sub>やB<sub>2</sub>O<sub>3</sub>に比べてP<sub>2</sub>O<sub>5</sub>は高分散側に位置する成分のためアッペ数3.2以下の光学特性を得るにはP<sub>2</sub>O<sub>5</sub>は少なくとも1.2%は必要である。逆に3.2%を超えると失透性が強くなり、安定なガラスが得られなくなるためP<sub>2</sub>O<sub>5</sub>の含量は1.2~3.2%の範囲に限定される。好ましいP<sub>2</sub>O<sub>5</sub>の含量

は14~30%の範囲である。

【0021】 $B_2O_3$ は焼成性ガラスにおいて適量添加により耐失透性が極めて良くなり、かつ、 $P_2O_5$ 、 $SiO_2$ といった他のガラス形成酸化物成分に比べてガラス屈伏点( $T_s$ )を下げる効果が大きい。そのため、本発明には欠かせない成分である。 $B_2O_3$ が0.5%未満であると上記のごとく耐失透性が悪くなり、ガラスの屈伏点( $T_s$ )が上昇し、16%を越えると目的とする高屈折率・高分散特性が得られなくなる。このため $B_2O_3$ は0.5~16%の範囲に限定される。好ましい $B_2O_3$ の含量は1~14%の範囲である。

【0022】 $Li_2O$ は、目的とするガラス屈伏点( $T_s$ )が570℃以下の低融点特性を得るために不可欠な成分である。 $Li_2O$ が0.3%未満であると目的とする低融点特性が得られなくなり、6%を越えると耐失透性が悪くなる。このため $Li_2O$ は0.3~6%の範囲に限定される。好ましい $Li_2O$ の含量は0.3~4%の範囲である。

【0023】 $Na_2O$ はガラスの屈伏温度( $T_s$ )を下げ、液相温度を下げる成分として欠かせない成分である。またガラスの粘性を下げることができるので低温で溶解が可能となり、白金るつぼの浸食による着色を抑えることができる。 $Na_2O$ が2%未満では失透性が強く上記の効果が得られない。また22%を越えると、耐失透性、化学的耐久性が悪くなる。従って $Na_2O$ の含量は2~22%の範囲に限定され、好ましくは4~20%の範囲である。

【0024】 $Nb_2O_5$ は、目的とする高屈折率・高分散特性を得るために不可欠な成分であり、また耐久性を上げる効果のある成分である。 $Nb_2O_5$ が8%未満であると目的とする高屈折率・高分散特性が得られなくなり、52%を越えると耐失透性が悪くなり、かつガラスの屈伏点( $T_s$ )が上昇する。このため $Nb_2O_5$ は8~52%の範囲に限定される。好ましい $Nb_2O_5$ の含量は10~50%の範囲である。

【0025】本発明の第2の態様の低融点光学ガラスは、後記の実施例からも明らかのように高屈折率で高分散特性を有し、かつ低融点特性を有している。例えば、屈折率は1.69~1.83の範囲にあり、アッペ数は32~21の範囲でガラス屈伏点( $T_s$ )は570℃以下の範囲である。また、液相温度(L-T)を下げることができ、かつガラス塊をプレスする際のガラス軟化点での失透性も従来品よりも優れている。

【0026】本発明の第2の態様の低融点光学ガラスは、前記成分以外に任意成分として更に、 $SiO_2$ 、 $GeO_2$ 、 $K_2O$ 、 $MgO$ 、 $CaO$ 、 $SrO$ 、 $BaO$ 、 $ZnO$ 、 $Al_2O_3$ 、 $TiO_2$ 、 $Ta_2O_5$ 、 $WO_3$ 、 $As_2O_3$ 、 $Sb_2O_3$ 等の成分を含むことができる。これら任意成分の含量は、重量%で表示して、 $SiO_2$ が0%~5%、 $GeO_2$ が0~1.2%、 $K_2O$ が0~12%

%、 $K_2O$ が0~12%、 $MgO$ が0~5%、 $CaO$ が0~5%、 $SrO$ が0~5%、 $BaO$ が0~12%、 $ZnO$ が0~5%、 $Al_2O_3$ が0~5%、 $TiO_2$ が0~12%、 $Ta_2O_5$ が0~5%、 $WO_3$ が0%以上20%未満、 $As_2O_3$ が0~2%、 $Sb_2O_3$ が0~2%である。

【0027】 $SiO_2$ 及び $GeO_2$ は、ガラスの安定性を上げる効果が非常に大きな成分である。しかし、 $SiO_2$ が5%を越え、 $GeO_2$ が1.2%を越えると目的とする高屈折率・高分散特性が得られなくなり、またガラスの屈伏点も上昇する。このため $SiO_2$ の含量は0%~5%、 $GeO_2$ は0~1.2%の範囲に限定される。好ましくは、 $SiO_2$ は0~4.5%の範囲、 $GeO_2$ は0~1.0%の範囲である。

【0028】 $K_2O$ はガラスの屈伏点( $T_s$ )を下げる効果が非常に大きな成分である。しかし、 $K_2O$ が1.2%を越えると耐失透性、化学的耐久性が悪化する。そのため $K_2O$ は0~1.2%の範囲に限定される。好ましくは、 $K_2O$ の含量は0~10%の範囲である。

【0029】アルカリ土類金属酸化物である $MgO$ 、 $CaO$ 、 $SrO$ 及び $BaO$ はガラスの液相温度を下げ安定性を増す効果が大きな成分である。しかし、 $MgO$ は5%を越え、 $CaO$ は5%を越え、 $SrO$ は5%を越え、 $BaO$ は1.2%を越えると、目的とする高屈折率・高分散特性が得られず、かつ耐失透性が悪くなる。このため $MgO$ 、 $CaO$ 及び $SrO$ の含量は、いずれも0~5%の範囲に限定され、 $BaO$ は0~1.2%の範囲に限定される。好ましくは、 $MgO$ 、 $CaO$ 及び $SrO$ はそれぞれ0~3%の範囲であり、 $BaO$ は0~1.0%の範囲である。

【0030】 $TiO_2$ 及び $WO_3$ は高屈折率・高分散特性を得る効果が大きい成分である。しかし、 $TiO_2$ は1.2%を越え、 $WO_3$ は2.0%以上になると、耐失透性が悪くなり、ガラスの屈伏点が上昇し、強く着色するようになる。このため $TiO_2$ は0~1.2%の範囲に限定され、 $WO_3$ は0%以上2.0%未満に限定される。好ましくは、 $TiO_2$ は0~1.0%の範囲で、 $WO_3$ は0~1.9.5%範囲である。

【0031】 $ZnO$ 、 $Ta_2O_5$ 及び $Al_2O_3$ は、耐失透性を損なわずに少量添加により、屈折率の調整をすることが可能な成分である。しかし、それぞれ5%を越えると耐失透性が悪くなる。そのため、それぞれの含量は0~5%の範囲に限定され、好ましくは0~3%の範囲である。

【0032】 $As_2O_3$ 及び $Sb_2O_3$ は、消色剤および消泡剤として有効である。しかし、2%を越える量の添加は耐失透性を悪くする。そのため、 $As_2O_3$ 及び $Sb_2O_3$ の含量はそれぞれ0~2%の範囲に限定される。尚、本発明の第2の態様の光学ガラスは、本発明の目的を損なわない範囲で、上記の成分以外の成分を含有

することもできる。

【0033】本発明の低融点光学ガラスは、第1の態様及び第2の態様いずれの場合も、原料として、 $P_2O_5$ は正磷酸 ( $H_3PO_4$ ) 、メタリン酸塩、五酸化二磷等、他の成分については炭酸塩、硝酸塩、酸化物等を適宜用いることが可能である。これらの原料を所要の割合に秤取し、混合して調合原料とし、これを1000℃～1200℃に加熱した熔解炉に投入し、熔解、消泡後、攪拌し、均一化してから鋳型に鋳込み徐冷することにより、本発明の低融点光学ガラスを得ることができる。

#### 【0034】

【実施例】以下、実施例によりさらに本発明について説明する。

##### 実施例1～14

本発明の低融点光学ガラス（第1の態様）の調合組成（重量%）及び光学的性能を表1及び2に示す。各ガラスの原料は、 $P_2O_5$ の場合 $H_3PO_4$ であり、 $Na_2O$ の場合 $Na_2CO_3$ であり、 $K_2O$ の場合 $KNO_3$ であり、 $Li_2O$ の場合 $Li_2CO_3$ であり、 $Cs_2O$ の場合 $Cs_2CO_3$ であり、 $MgO$ の場合 $MgCO_3$ であ

り、 $CaO$ の場合 $CaCO_3$ であり、 $SrO$ の場合 $Sr(NO_3)_2$ であり、 $BaO$ の場合 $BaCO_3$ であり、 $B_2O_3$ の場合 $H_3BO_3$ であり、その他の成分については、表1及び2に示した酸化物をそのまま使用した。表1及び2の実施例1～14に示した各ガラスは、定められた組成に調合した後、白金坩埚を用いて1000℃～1200℃で熔解した。30～40分熔解し均質化した後、金型に鋳込み徐冷することによりガラスを得た。

【0035】表中の屈折率 ( $n_d$ ) 、アッペ数 ( $\nu_d$ ) は徐冷降溫速度-30℃/hrにした場合の結果である。ガラス転移点  $T_g$ 、ガラス屈伏点 ( $T_s$ ) は熱膨張測定機を用いて8℃/minで昇温した場合の測定結果である。液相温度 ( $L \cdot T$ ) は400℃～1050℃の温度勾配のついた失透試験炉に30分保持し、倍率80倍の顕微鏡により結晶の有無を観察し、軟化点付近の失透性も液相温度測定の際同時に目視により観察した結果である。

#### 【0036】

【表1】

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	実施例						
	1	2	3	4	5	6	7
P <sub>2</sub> O <sub>5</sub>	4.4	24.4	17.4	14.4	18.4	19.4	15.4
B <sub>2</sub> O <sub>3</sub>	2.5	2.5	12.5	—	1.0	2.5	5.5
GeO <sub>2</sub>	24.0	8.0	8.0	8.0	—	4.0	4.0
Na <sub>2</sub> O	7.8	10.0	10.0	10.0	5.0	20.0	10.0
K <sub>2</sub> O	—	3.8	0.8	—	7.8	2.8	12.8
BaO	5.0	5.0	5.0	11.8	—	3.0	3.0
TiO <sub>2</sub>	5.0	2.0	5.0	4.5	—	6.0	6.0
Nb <sub>2</sub> O <sub>5</sub>	12.6	9.1	7.6	10.6	21.1	16.6	12.6
WO <sub>3</sub>	38.7	35.2	33.7	38.7	46.7	25.7	30.7
Li <sub>2</sub> O				2.0			
As <sub>2</sub> O <sub>3</sub>					0.2		
Sb <sub>2</sub> O <sub>3</sub>						0.2	
Cs <sub>2</sub> O							
MgO							
CaO							
SrO							
ZnO							
Ta <sub>2</sub> O <sub>5</sub>							
n <sub>d</sub>	1.85225	1.70266	1.72277	1.77908	1.80025	1.72361	1.70035
v <sub>d</sub>	21.8	32.3	26.5	26.4	23.33	34.5	29.13
T <sub>g</sub>	502	494	479	442	539	453	404
T <sub>s</sub>	534	533	529	475	568	489	444
L·T	940	認めず	850	800	900	830	730
軟化点 失透性	透明						

[0037]

[表2]

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	実 施 例						
	8	9	10	11	12	13	14
P <sub>2</sub> O <sub>5</sub>	18.4	13.4	17.4	13.4	17.4	16.4	18.4
B <sub>2</sub> O <sub>3</sub>	2.5	1.0	2.5	1.0	3.5	2.5	—
CaO	4.0	8.0	4.0	8.0	4.0	8.0	—
Na <sub>2</sub> O	17.0	10.0	10.0	10.8	10.0	10.0	10.0
K <sub>2</sub> O	2.8	0.8	2.8	—	2.8	0.8	2.8
BaO	3.0	8.0	6.0	8.0	—	5.0	—
TiO <sub>2</sub>	6.0	4.5	6.0	4.5	6.0	13.0	3.0
Nb <sub>2</sub> O <sub>5</sub>	12.6	12.6	12.6	12.6	12.6	10.6	16.1
WO <sub>3</sub>	30.7	38.7	35.7	38.7	39.7	33.7	45.7
Li <sub>2</sub> O							
As <sub>2</sub> O <sub>3</sub>							
Sb <sub>2</sub> O <sub>3</sub>							
Ge <sub>2</sub> O	3.0						
MgO		3.0					
CaO			3.0				
SrO				3.0			
ZnO					4.0		
Ta <sub>2</sub> O <sub>5</sub>						4.0	
n <sub>d</sub>	1.70815	1.79671	1.79909	1.80215	1.79765	1.84190	1.82682
ν <sub>s</sub>	31.3	26.49	24.56	24.76	23.74	22.7	22.27
T <sub>g</sub>	411	489	515	487	494	532	511
T <sub>s</sub>	448	515	547	515	527	568	549
L · T	800	890	750	780	793	950	850
軟化点 失透性	透明						

## 【0038】比較例1～11

特公昭56-40094号公報に記載の実施例7と14のガラスを比較用ガラスとして、その屈折率、アッペ数、液相温度、ガラス屈伏点（T<sub>s</sub>）を測定した。結果を表3（比較例1、比較例2）に示す。この比較ガラスはNb<sub>2</sub>O<sub>5</sub>を多く含んでいるため、耐失透性が悪くガラス屈伏点も600℃以上と精密プレス成形用ガラスとしては実用的でないことがわかる。比較例3のガラスは、特開昭63-265840号公報に記載の実施例4のガラスの屈折率、アッペ数、液相温度（L · T）、ガラス屈伏点（T<sub>s</sub>）を測定した結果である（表3）。このガラスもガラス屈伏点が622℃と高く、軟化点付近で30分間保持するとガラスが失透してしまうため、実用的でないことがわかる。比較例4のガラスは、特開平

1-308843号公報に記載の実施例29のガラスの屈折率、アッペ数、ガラス屈伏点（T<sub>s</sub>）を測定した結果である（表3）。このガラスはガラス屈伏点が428℃と非常に低いが、PbOを多量に含むため還元性雰囲気でガラスをプレスするとPbOが還元され型に付着し、その後精密プレスが不可能となり実用的でないことがわかる。

【0039】比較例5～11（表3及び4）のガラスは、特開平5-51233号公報に記載の実施例1、2、3、4、5、6、8のガラスの屈折率、アッペ数、ガラス屈伏点（T<sub>s</sub>）を測定した結果である。これらのガラスはガラス熔解中にガラスが失透したり、熔解後キャストしてガラスになったものでも液相温度は1000℃以上と高く、軟化点付近で30分間保持するとガラス

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が失透してしまうため、いずれも実用的でないことが分かる。

[0040]  
[表3]

117-05  
合計

	比 較 例					
	1	2	3	4	5	6
P <sub>2</sub> O <sub>5</sub>	31.3	19.4	3.5			
B <sub>2</sub> O <sub>3</sub>			1.5	15.0	5.0	
GeO <sub>2</sub>					7.0	15.0
SiO <sub>2</sub>			22.0	15.0	12.0	10.0
Li <sub>2</sub> O				4.0	1.3	
Na <sub>2</sub> O					10.7	15.0
K <sub>2</sub> O	16.2	12.8	20.0		7.5	3.0
Cs <sub>2</sub> O					8.5	10.0
ZnO	4.8		0.5	4.0		
PbO				57.0		
BeO					3.3	
TiO <sub>2</sub>	24.8		23.0		25.7	20.0
Nb <sub>2</sub> O <sub>5</sub>	22.9	22.1	29.0		19.0	27.0
WO <sub>3</sub>		45.7				
La <sub>2</sub> O <sub>3</sub>				0.5		
ZrO <sub>2</sub>				0.2		
CeO				4.0		
Sb <sub>2</sub> O <sub>3</sub>				0.3		
As <sub>2</sub> O <sub>3</sub>			0.5			
n <sub>d</sub>	1.8178	1.7874	1.7982	1.774	1.8055	1.81491
ν <sub>d</sub>	21.8	24.1	23.1	29.9	25.2	24.6
Tg	—	577	596	392		
Ts	—	608	622	428	520	546
L·T	熔解中 失透	950	1050 <		1050 <	熔解中 失透
軟化点 失透性		透明	失透		失透	

[0041]

[表4]

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	比較例				
	7	8	9	10	11
P <sub>2</sub> O <sub>5</sub>					
B <sub>2</sub> O <sub>3</sub>					
GeO <sub>2</sub>	9.0	10.0	5.0	3.5	9.0
SiO <sub>2</sub>	13.0	15.0	19.0	19.0	15.0
Li <sub>2</sub> O		2.0	1.0		1.3
Na <sub>2</sub> O	16.0	10.0	10.0	12.0	9.0
K <sub>2</sub> O	10.0			9.0	9.2
Ca <sub>2</sub> O		15.0	19.0	8.5	8.5
ZnO					
PbO					
BaO		5.0			3.3
TiO <sub>2</sub>	27.0	25.0	25.0	26.5	25.7
Nb <sub>2</sub> O <sub>5</sub>	25.0	18.0	21.0	21.5	19.0
WO <sub>3</sub>					
La <sub>2</sub> O <sub>3</sub>					
ZrO <sub>2</sub>					
CaO					
Sb <sub>2</sub> O <sub>3</sub>					
As <sub>2</sub> O <sub>3</sub>					
n <sub>d</sub>	1.80516	1.82633	1.79850	1.78946	1.80832
v <sub>d</sub>	24.5	24.8	25.2	25.0	25.2
Tg					
Ts	520	537	543	550	542
L·T	熔解中 失透	熔解中 失透	1010	1025	1050℃
軟化点 失透性			失透	失透	失透

【0042】比較例の各ガラスと比較して、表1及び2に示すように、実施例1～14の本発明のガラスは、高屈折率かつ高分散の低融点ガラスである。さらに、実施例1～14の本発明のガラスは、ガラス屈伏点(Ts)が570℃以下で、ガラスの液相温度(L·T)はすべて950℃以下であり、軟化点付近でガラスを30分間保持してもガラスは失透することがなかった。従って、いずれのガラスも精密プレスによるレンズを大量に生産することが可能な安定性を有することが分かる。

【0043】実施例21～30

本発明の低融点光学ガラス(第2の態様)の組成(重量%)及び光学的性能を表5及び6に示す。各ガラ

スの原料は、P<sub>2</sub>O<sub>5</sub>の場合H<sub>3</sub>PO<sub>4</sub>であり、Na<sub>2</sub>Oの場合Na<sub>2</sub>CO<sub>3</sub>であり、K<sub>2</sub>Oの場合KNO<sub>3</sub>であり、Li<sub>2</sub>Oの場合Li<sub>2</sub>CO<sub>3</sub>であり、Al<sub>2</sub>O<sub>3</sub>の場合Al(OH)<sub>3</sub>であり、MgOの場合MgCO<sub>3</sub>であり、CaOの場合CaCO<sub>3</sub>であり、SrOの場合Sr(NO<sub>3</sub>)<sub>2</sub>であり、BaOの場合BaCO<sub>3</sub>であり、B<sub>2</sub>O<sub>3</sub>の場合H<sub>3</sub>BO<sub>3</sub>である。その他の成分については、表5及び6に示した酸化物をそのまま使用した。表5及び6の実施例21～30に示した各ガラスは、定められた組成によって調合した後、白金坩埚を用いて1000℃～1200℃で熔解した。30～40分熔解し均質化した後、金型に鋳込み徐冷することにより

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ガラスを得た。

【0044】表中の屈折率 ( $n_d$ )、アッペ数 ( $\nu_d$ ) は徐冷降温速度 $-30^{\circ}\text{C}/\text{hr}$ にした場合の結果である。ガラス転移点 ( $T_g$ )、ガラス屈伏点 ( $T_s$ ) 热膨胀測定機を用いて $8^{\circ}\text{C}/\text{min}$ で昇温した場合の結果である。又、液相温度 ( $L \cdot T$ ) は $400^{\circ}\text{C} \sim 1050^{\circ}\text{C}$

の温度勾配のついた失透試験炉に30分保持し、倍率80倍の顕微鏡により結晶の有無を観察し、軟化点付近の失透性も液相温度測定の際同時に目視により観察した結果である。

【0045】

【表5】

	実 施 例				
	21	22	23	24	25
$\text{P}_2\text{O}_5$	23.4	28.0	21.4	21.4	21.4
$\text{B}_2\text{O}_3$	3.0	1.1	8.8	5.6	5.6
$\text{SiO}_2$	—	4.4	4.5	4.5	4.5
$\text{GeO}_2$	10.0	—	—	—	—
$\text{Li}_2\text{O}$	0.5	1.0	0.5	1.0	3.0
$\text{Na}_2\text{O}$	13.5	18.5	5.0	9.5	7.5
$\text{K}_2\text{O}$	2.8	2.0	8.8	7.0	7.0
$\text{TiO}_2$	6.0	9.2	—	9.2	9.2
$\text{Nb}_2\text{O}_5$	12.6	35.6	48.0	38.8	38.8
$\text{WO}_3$	19.5				
$\text{BaO}$	8.7				
$\text{Sb}_2\text{O}_3$		0.2			
$\text{Al}_2\text{O}_3$			3.0		
$\text{MgO}$				3.0	
$\text{CaO}$					3.0
$n_d$	1.69121	1.74812	1.75431	1.77520	1.77820
$\nu_d$	30.5	25.7	25.1	26.2	26.1
$T_s$	565	551	562	560	550
$L \cdot T$	930	930	930	920	910
軟化点 失透性	透明	透明	透明	透明	透明

【0046】

【表6】

( 11 )

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	実 施 例				
	2 6	2 7	2 8	2 9	3 0
P <sub>2</sub> O <sub>5</sub>	21.4	24.4	24.4	21.4	15.4
B <sub>2</sub> O <sub>3</sub>	5.6	4.1	4.1	4.6	12.5
SiO <sub>2</sub>	4.5	4.0	4.0	4.5	—
GeO <sub>2</sub>	—	—	—	—	8.0
Li <sub>2</sub> O	1.0	1.0	1.0	1.0	0.5
Na <sub>2</sub> O	9.5	16.5	16.5	9.5	10.3
K <sub>2</sub> O	7.0	4.0	4.0	7.0	—
TiO <sub>2</sub>	9.2	9.2	9.2	9.2	5.0
Nb <sub>2</sub> O <sub>5</sub>	38.8	33.8	33.8	42.6	37.7
SrO	3.0				
ZnO		3.0			
Ta <sub>2</sub> O <sub>5</sub>			3.0		
As <sub>2</sub> O <sub>3</sub>				0.2	
WO <sub>3</sub>					5.6
BaO					5.0
n <sub>d</sub>	1.77745	1.74713	1.75138	1.81509	1.76371
v <sub>d</sub>	26.3	26.1	26.5	22.66	25.1
T <sub>s</sub>	558	520	542	568	555
L・T	890	880	920	930	890
軟化点 失透性	透明	透明	透明	透明	透明

【0047】前記表3の比較例1、2の特公昭56-40094号公報に記載の比較ガラスはガラス形成酸化物として、P<sub>2</sub>O<sub>5</sub>だけを用いているため耐失透性が悪く、ガラス屈伏点(T<sub>s</sub>)も高い。またガラスの屈伏点を下げるのに最も効果の高いアルカリ金属酸化物としてK<sub>2</sub>Oのみを用いているためガラス屈伏点が高く、精密プレス成形用ガラスとしては実用的でない。さらに表3及び4の比較例3～11のガラスは前記のようにそれぞれ問題点がある。

【0048】それに対して実施例21～30の本発明のガラスは、高屈折率・高分散の低融点ガラスであり、ガラス屈伏点(T<sub>s</sub>)が570℃以下で、ガラスの液相温

度(L・T)はすべて950℃以下である。実施例21～30のガラスは、軟化点付近でガラスを30分間保持してもガラスは失透することがなかった。従って、いづれのガラスも精密プレスによるレンズを大量に生産することが可能な安定性を有することが分かる。

#### 【0049】

【発明の効果】本発明によれば、高屈折率・高分散特性を有するとともに、ガラス屈伏点が570℃以下で耐失透性を有し安定であり、かつ、成形性にすぐれた低融点光学ガラスを提供することができる。本発明の低融点光学ガラスを用いることにより、精密プレス用の成形型の寿命を延ばしてレンズを生産することが可能である。

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	1	2	3	4	5	6	7
Composition	wt%	wt%	wt%	wt%	wt%	wt%	wt%
SiO <sub>2</sub>							
B <sub>2</sub> O <sub>3</sub>	2.5	2.5	12.5	0	1	2.5	5.5
Al <sub>2</sub> O <sub>3</sub>							
P <sub>2</sub> O <sub>5</sub>	4.4	24.4	17.4	14.4	18.4	19.4	15.4
Li <sub>2</sub> O	0	0	0	2	0	0	0
Na <sub>2</sub> O	7.8	10	10	10	5	20	10
K <sub>2</sub> O	0	3.8	0.8	0	7.8	2.8	12.8
Cs <sub>2</sub> O	0	0	0	0	0	0	0
MgO							
CaO							
SrO							
BaO	5	5	5	11.8	0	3	3
ZnO							
TiO <sub>2</sub>	5	2	5	4.5	0	6	6
Nb <sub>2</sub> O <sub>5</sub>	12.6	9.1	7.6	10.6	21.1	16.6	12.6
Ta <sub>2</sub> O <sub>5</sub>							
WO <sub>3</sub>	38.7	35.2	33.7	38.7	48.7	25.7	30.7
Sb <sub>2</sub> O <sub>3</sub>	0	0	0	0	0	0.2	0
As <sub>2</sub> O <sub>3</sub>	0	0	0	0	0.2	0	0
GeO <sub>2</sub>	24	8	8	8	0	4	4
合計	100	100	100	100	100.2	100.2	100

	1	2	3	4	5	6	7
Composition	mol%						
SiO <sub>2</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B <sub>2</sub> O <sub>3</sub>	4.91	4.92	21.97	0.00	2.44	4.32	9.91
Al <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P <sub>2</sub> O <sub>5</sub>	4.24	23.55	14.99	13.59	22.00	16.43	13.60
Li <sub>2</sub> O	0.00	0.00	0.00	8.99	0.00	0.00	0.00
Na <sub>2</sub> O	17.20	22.11	19.73	21.61	13.69	38.79	20.23
K <sub>2</sub> O	0.00	5.53	1.04	0.00	14.06	3.57	17.04
Cs <sub>2</sub> O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BaO	4.47	4.48	4.00	10.33	0.00	2.36	2.46
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TiO <sub>2</sub>	8.55	3.43	7.65	7.55	0.00	9.03	9.42
Nb <sub>2</sub> O <sub>5</sub>	6.48	4.69	3.50	5.34	13.48	7.51	5.95
Ta <sub>2</sub> O <sub>5</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WO <sub>3</sub>	22.80	20.80	17.77	22.35	34.17	13.32	16.60
Sb <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.08	0.00
As <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.17	0.00	0.00
GeO <sub>2</sub>	31.36	10.48	9.36	10.25	0.00	4.60	4.80
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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	Emdobiiment						
	8	9	10	11	12	13	14
Composition	wt%	wt%	wt%	wt%	wt%	wt%	wt%
SiO <sub>2</sub>							
B <sub>2</sub> O <sub>3</sub>	2.5	1	2.5	1	3.5	2.5	0
Al <sub>2</sub> O <sub>3</sub>							
P <sub>2</sub> O <sub>5</sub>	18.4	13.4	17.4	13.4	17.4	16.4	18.4
Li <sub>2</sub> O	0	0	0	0	0	0	0
Na <sub>2</sub> O	17	10	10	10.8	10	10	10
K <sub>2</sub> O	2.8	0.8	2.8	0	2.8	0.8	2.8
Cs <sub>2</sub> O	3	0	0	0	0	0	0
MgO		3					
CaO			3				
SrO				3			
BaO	3	8	6	8	0	5	0
ZnO					4		
TiO <sub>2</sub>	6	4.5	6	4.5	6	13	3
Nb <sub>2</sub> O <sub>5</sub>	12.6	12.6	12.6	12.6	12.6	10.6	16.1
Ta <sub>2</sub> O <sub>5</sub>							4
WO <sub>3</sub>	30.7	38.7	35.7	38.7	39.7	33.7	45.7
Sb <sub>2</sub> O <sub>3</sub>	0	0	0	0	0	0	0
As <sub>2</sub> O <sub>3</sub>	0	0	0	0	0	0	0
GeO <sub>2</sub>	4	8	4	8	4	8	0
合計	100	100	100	100	100	100	100

	Emdobiiment						
	8	9	10	11	12	13	14
Composition	mol%	mol%	mol%	mol%	mol%	mol%	mol%
SiO <sub>2</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B <sub>2</sub> O <sub>3</sub>	4.53	1.91	4.75	2.02	6.75	4.62	0.00
Al <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P <sub>2</sub> O <sub>5</sub>	16.35	12.54	16.19	13.27	16.45	14.84	20.74
Li <sub>2</sub> O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na <sub>2</sub> O	34.59	21.44	21.31	24.49	21.65	20.73	25.82
K <sub>2</sub> O	3.75	1.13	3.93	0.00	3.99	1.09	4.76
Cs <sub>2</sub> O	1.34	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	9.90	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	7.07	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	4.07	0.00	0.00	0.00
BaO	2.47	6.95	5.18	7.35	0.00	4.20	0.00
ZnO	0.00	0.00	0.00	0.00	6.60	0.00	0.00
TiO <sub>2</sub>	9.47	7.49	9.92	7.92	10.08	20.91	6.01
Nb <sub>2</sub> O <sub>5</sub>	5.98	6.30	6.26	6.67	6.36	5.12	9.70
Ta <sub>2</sub> O <sub>5</sub>	0.00	0.00	0.00	0.00	0.00	0.00	1.45
WO <sub>3</sub>	16.69	22.17	20.33	23.46	22.97	18.67	31.53
Sb <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GeO <sub>2</sub>	4.82	10.17	5.05	10.75	5.13	9.83	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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	21	22	23	24	25	26	27
Composition	wt%						
SiO <sub>2</sub>	0	4.4	4.5	4.5	4.5	4.5	4
B <sub>2</sub> O <sub>3</sub>	3	1.1	8.8	5.6	5.6	5.8	4.1
Al <sub>2</sub> O <sub>3</sub>	0	0	3	0	0	0	0
P <sub>2</sub> O <sub>5</sub>	23.4	28	21.4	21.4	21.4	21.4	24.4
Li <sub>2</sub> O	0.5	1	0.5	1	3	1	1
Na <sub>2</sub> O	13.5	18.5	5	9.5	7.5	9.5	16.5
K <sub>2</sub> O	2.8	2	8.8	7	7	7	4
Cs <sub>2</sub> O							
MgO	0	0	0	3	0	0	0
CaO	0	0	0	0	3	0	0
SrO	0	0	0	0	0	3	0
BaO	8.7	0	0	0	0	0	0
ZnO							3
TiO <sub>2</sub>	6	9.2	0	9.2	9.2	9.2	9.2
Nb <sub>2</sub> O <sub>5</sub>	12.6	35.6	48	38.8	38.8	38.8	33.8
Ta <sub>2</sub> O <sub>5</sub>							
WO <sub>3</sub>	19.5	0	0	0	0	0	0
Sb <sub>2</sub> O <sub>3</sub>	0	0.2	0	0	0	0	0
As <sub>2</sub> O <sub>3</sub>							
GeO <sub>2</sub>	10	0	0	0	0	0	0
合計	100	100	100	100	100	100	100

	21	22	23	24	25	26	27
Composition	mol%						
SiO <sub>2</sub>	0.00	8.23	9.95	8.29	8.17	8.73	7.25
B <sub>2</sub> O <sub>3</sub>	5.19	1.78	16.79	8.91	8.78	9.39	6.41
Al <sub>2</sub> O <sub>3</sub>	0.00	0.00	3.91	0.00	0.00	0.00	0.00
P <sub>2</sub> O <sub>5</sub>	19.83	22.18	20.02	16.69	16.44	17.58	18.71
Li <sub>2</sub> O	2.02	3.77	2.23	3.72	10.98	3.91	3.65
Na <sub>2</sub> O	26.20	33.56	10.71	16.97	13.20	17.87	28.97
K <sub>2</sub> O	3.58	2.39	12.41	8.23	8.11	8.67	4.62
Cs <sub>2</sub> O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	8.25	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	5.83	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	3.38	0.00
BaO	6.84	0.00	0.00	0.00	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	4.01
TiO <sub>2</sub>	9.03	12.95	0.00	12.76	12.56	13.43	12.53
Nb <sub>2</sub> O <sub>5</sub>	5.70	15.06	23.99	16.17	15.93	17.03	13.84
Ta <sub>2</sub> O <sub>5</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WO <sub>3</sub>	10.11	0.00	0.00	0.00	0.00	0.00	0.00
Sb <sub>2</sub> O <sub>3</sub>	0.00	0.08	0.00	0.00	0.00	0.00	0.00
As <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GeO <sub>2</sub>	11.50	0.00	0.00	0.00	0.00	0.00	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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				Comparative Example		
	28	29	30	1	2	3
Composition	wt%	wt%	wt%	wt%	wt%	wt%
SiO <sub>2</sub>	4	4.5	0			22
B <sub>2</sub> O <sub>3</sub>	4.1	4.6	12.5			1.5
Al <sub>2</sub> O <sub>3</sub>	0	0	0			
P <sub>2</sub> O <sub>5</sub>	24.4	21.4	15.4	31.3	19.4	3.5
Li <sub>2</sub> O	1	1	0.5			
Na <sub>2</sub> O	16.5	9.5	10.3			
K <sub>2</sub> O	4	7	0	16.2	12.8	20
Cs <sub>2</sub> O						
MgO	0	0	0			
CaO	0	0	0			
SrO	0	0	0			
BaO	0	0	5			
ZnO				4.8		0.5
TiO <sub>2</sub>	9.2	9.2	5	24.8		23
Nb <sub>2</sub> O <sub>5</sub>	33.8	42.6	37.7	22.9	22.1	29
Ta <sub>2</sub> O <sub>5</sub>	3					
WO <sub>3</sub>	0	0	5.6		45.7	
Sb <sub>2</sub> O <sub>3</sub>	0	0	0			
As <sub>2</sub> O <sub>3</sub>		0.2				0.5
GeO <sub>2</sub>	0	0	8			
合計	100	100	100	100	100	100

				Comparative Example		
	28	29	30	1	2	3
Composition	mol%	mol%	mol%	mol%	mol%	mol%
SiO <sub>2</sub>	7.49	9.03	0.00	0.00	0.00	35.53
B <sub>2</sub> O <sub>3</sub>	6.83	7.97	22.21	0.00	0.00	2.09
Al <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00
P <sub>2</sub> O <sub>5</sub>	19.34	18.17	13.41	26.00	24.72	2.39
Li <sub>2</sub> O	3.78	4.05	2.07	0.00	0.00	0.00
Na <sub>2</sub> O	29.95	18.48	20.54	0.00	0.00	0.00
K <sub>2</sub> O	4.78	8.98	0.00	20.28	24.59	20.81
Cs <sub>2</sub> O	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	0.00
BaO	0.00	0.00	4.04	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	6.95	0.00	0.60
TiO <sub>2</sub>	12.96	13.89	7.74	36.61	0.00	27.94
Nb <sub>2</sub> O <sub>5</sub>	14.31	19.33	17.54	10.16	15.05	10.59
Ta <sub>2</sub> O <sub>5</sub>	0.76	0.00	0.00	0.00	0.00	0.00
WO <sub>3</sub>	0.00	0.00	2.98	0.00	35.64	0.00
Sb <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00
As <sub>2</sub> O <sub>3</sub>	0.00	0.12	0.00	0.00	0.00	0.25
GeO <sub>2</sub>	0.00	0.00	9.46	0.00	0.00	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00

Table 8

Example	$\lambda_{5}$ (nm)	$\lambda_{80}$ (nm)
Ex.78	378	470
Ex.79	371	475
Ex.80	371	478
Ex.81	371	487
Ex.82	371	490
Ex.83	371	488

## [0081]

## (1) Refractive index [nd] and Abbé number [vd]

These were measured for optical glass obtained at a gradual cooling temperature reduction rate of -30°C/h.

## (2) Transition temperature [Tg] and yield point temperature [Ts]

These were measured at a rate of temperature rise of 4°C/min with a thermomechanical analyzer from Rignku Denki K.K.

## (3) Liquid phase temperature (LT)

The optical glass was kept in a loss of transparency test furnace with a 400-1,100°C temperature gradient, the presence or absence of crystals was observed with a microscope at 80-fold magnification, and the liquid phase temperature was measured.

## (4) Viscosity at liquid-phase temperature

The viscosity at the liquid phase temperature was measured by the rotating cylinder (Margules) method (Naruse, Habuku, "Glass Engineering" (Kyotatsu Shuppan).

## [0082]

## Comparative Examples 1-3

Comparative Examples 1-3 are Embodiment 9 described in Japanese Patent Unexamined Publication No. Sho 55-37500, Embodiment 4 described in Japanese Patent Unexamined Publication No. Sho 56-40094, and Embodiment 1 described in Japanese Patent Unexamined Publication No. Hei 5-51233. These glasses are given as comparative examples. The characteristics of these glasses were measured in the same manner as for the embodiments. The results are given in Table 9.

**Additional claims to be submitted in US09/893,958****Claims below are all new claims**

117. An optical glass comprising, as molar percentages,  
12-34 percent of  $P_2O_5$ ;  
0.2-15 percent of  $B_2O_3$   
(where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent);  
2-40 percent of  $WO_3$ ;  
0-25 percent of  $Nb_2O_5$ ;  
0 to 10 percent of  $TiO_2$   
(where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent);  
0-25 percent of  $BaO$ ;  
0-20 percent of  $ZnO$   
(where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent);  
2-30 percent of  $Li_2O$ ;  
2-30 percent of  $Na_2O$ ;  
0-15 percent of  $K_2O$   
(where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 29-45 percent);  
0-10 percent of  $CaO$ ;  
0-10 percent of  $SrO$ ;  
0-5 percent of  $Al_2O_3$ ;  
0-5 percent of  $Y_2O_3$ ;  
0-1 percent of  $Sb_2O_3$ ; and  
0-1 percent of  $As_2O_3$ ;  
where the total quantity of all of the above-listed components is equal to or more than 94 percent; and  
wherein said optical glass has comprises, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $Nb_2O_5$ ,  $TiO_2$ ,  $BaO$ ,  $ZnO$ ,  $Li_2O$ ,  $Na_2O$  and  $K_2O$ ; and does not comprise an amount of  $GeO_2$ .

This claim is supported by originally filed claims 15, 18 and 26, and the underlined part was derived from originally filed claims 18 and 26. Please note that in originally filed claims 15, it is defined to 2-45 percent of WO<sub>3</sub> but in the above claim it is defined to 2-40 percent of WO<sub>3</sub>. This is supported by the description on page 14, line 5.

118. An optical glass comprising, as molar percentages,  
12-34 percent of P<sub>2</sub>O<sub>5</sub>;  
0.2-15 percent of B<sub>2</sub>O<sub>3</sub>  
(where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent);  
2-40 percent of WO<sub>3</sub>;  
0-25 percent of Nb<sub>2</sub>O<sub>5</sub>;  
0 to 10 percent of TiO<sub>2</sub>  
(where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent);  
0-11 percent of BaO;  
0-20 percent of ZnO  
(where the total quantity of BaO and ZnO is less than 30 percent);  
2-30 percent of Li<sub>2</sub>O;  
2-30 percent of Na<sub>2</sub>O;  
0-15 percent of K<sub>2</sub>O  
(where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent);  
0-10 percent of CaO;  
0-10 percent of SrO;  
0-5 percent of Al<sub>2</sub>O<sub>3</sub>;  
0-5 percent of Y<sub>2</sub>O<sub>3</sub>;  
0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and  
0-1 percent of As<sub>2</sub>O<sub>3</sub>;  
where the total quantity of all of the above-listed components is equal to or more than 94 percent; and

wherein said optical glass has comprises, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  
 $Nb_2O_5$ ,  $TiO_2$ ,  $BaO$ ,  $ZnO$ ,  $Li_2O$ ,  $Na_2O$  and  $K_2O$ ; and does not comprise an amount of  
 $GeO_2$ .

This claim is supported by originally filed claims 16, 19 and 27, and the underlined part  
was derived from originally filed claims 19 and 27. Please note that in originally filed  
claims 16, it is defined to 2-45 percent of  $WO_3$  but in the above claim it is defined to 2-40  
percent of  $WO_3$ . This is supported by the description on page 14, line 5.

119. The optical glass of claim 117 wherein said optical glass has the composition comprising  $Sb_2O_3$ .

120. The optical glass of claim 118 wherein said optical glass has the composition comprising  $Sb_2O_3$ .

These claims are supported by originally filed claims 18 and 19.

121. The optical glass of claim 117 wherein the content of  $TiO_2$  is 2 percent or more.

122. The optical glass of claim 117 wherein the content of  $K_2O$  is 1 percent or more.

123. The optical glass of claim 118 wherein the content of  $TiO_2$  is 2 percent or more.

124. The optical glass of claim 118 wherein the content of  $K_2O$  is 1 percent or more.

Claims 121 and 123 are supported by [0027] and claims 122 and 124 are supported by  
[0029] of the application.

125. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than 0.4 Pa · s, wherein said optical glass has the

composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, TiO<sub>2</sub>, and K<sub>2</sub>O, does not comprise substantial amount of GeO<sub>2</sub>, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent (excluding 0 percent) of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'<sub>2</sub>O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O (where the quantity of K<sub>2</sub>O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

126. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, TiO<sub>2</sub>, and K<sub>2</sub>O, does not comprise substantial amount of GeO<sub>2</sub>, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent (excluding 0 percent) of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'<sub>2</sub>O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O (where the quantity of K<sub>2</sub>O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

127. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, and TiO<sub>2</sub>, does not comprise substantial amount of GeO<sub>2</sub>, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent (excluding 0 percent) of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'<sub>2</sub>O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O; and 0-30 percent (excluding 30

percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

128. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, and TiO<sub>2</sub>, does not comprise substantial amount of GeO<sub>2</sub>, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent (excluding 0 percent) of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'₂O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O; and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

129. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, TiO<sub>2</sub>, and K<sub>2</sub>O, dose not comprise substantial amount of GeO<sub>2</sub>, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent (excluding 0 percent) of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'₂O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O (where the quantity of K<sub>2</sub>O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

130. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than 0.4 Pa · s, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $TiO_2$ , and  $K_2O$ , does not comprise substantial amount of  $GeO_2$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2 to 10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 1-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

131. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $TiO_2$ , and  $K_2O$ , does not comprise substantial amount of  $GeO_2$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2 to 10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 1-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

132. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ , and  $TiO_2$ , does not comprise substantial amount of  $GeO_2$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2 to 10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

133. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ , and  $TiO_2$ , does not comprise substantial amount of  $GeO_2$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2 to 10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ .

percent of  $\text{As}_2\text{O}_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

134. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda 80$  is equal to or less than 500nm and a transmittance  $\lambda 5$  is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $\text{P}_2\text{O}_5$ ,  $\text{B}_2\text{O}_3$ ,  $\text{WO}_3$ ,  $\text{TiO}_2$ , and  $\text{K}_2\text{O}$ , does not comprise substantial amount of  $\text{GeO}_2$ , and comprises, as molar percentages, 12-34 percent of  $\text{P}_2\text{O}_5$ ; 0.2-15 percent of  $\text{B}_2\text{O}_3$  (where the total quantity of  $\text{P}_2\text{O}_5$  and  $\text{B}_2\text{O}_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $\text{WO}_3$ ; 0-25 percent of  $\text{Nb}_2\text{O}_5$ ; 2 to 10 percent of  $\text{TiO}_2$  (where the total quantity of  $\text{WO}_3$ ,  $\text{Nb}_2\text{O}_5$ , and  $\text{TiO}_2$  is 20-45 percent); 0-25 percent of  $\text{BaO}$ ; 0-20 percent of  $\text{ZnO}$  (where the total quantity of  $\text{BaO}$  and  $\text{ZnO}$  is less than 30 percent); 2-30 percent of  $\text{Li}_2\text{O}$ ; 2-30 percent of  $\text{Na}_2\text{O}$ ; 1-15 percent of  $\text{K}_2\text{O}$  (where the total quantity of  $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}$ , and  $\text{K}_2\text{O}$  is 10-45 percent); 0-10 percent of  $\text{CaO}$ ; 0-10 percent of  $\text{SrO}$ ; 0-5 percent of  $\text{Al}_2\text{O}_3$ ; 0-5 percent of  $\text{Y}_2\text{O}_3$ ; 0-1 percent of  $\text{Sb}_2\text{O}_3$ ; and 0-1 percent of  $\text{As}_2\text{O}_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

135. An optical glass having the composition comprising, as essential components,  $\text{P}_2\text{O}_5$ ,  $\text{B}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{WO}_3$ ,  $\text{TiO}_2$ , and  $\text{K}_2\text{O}$ , not comprising substantial amount of  $\text{GeO}_2$ , and comprising, as molar percentages, 15-30 percent of  $\text{P}_2\text{O}_5$ ; 0.5-15 percent of  $\text{B}_2\text{O}_3$ ; 5-25 percent of  $\text{Nb}_2\text{O}_5$ ; 0-40 percent (excluding 0 percent) of  $\text{WO}_3$ ; 2-10 percent of  $\text{TiO}_2$ ; 4-45 percent of at least one  $\text{R}'_2\text{O}$  selected from among  $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}$ , and  $\text{K}_2\text{O}$  (where the quantity of  $\text{K}_2\text{O}$  is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one  $\text{RO}$  selected from among  $\text{BaO}$ ,  $\text{ZnO}$ , and  $\text{SrO}$ ; with the total content of the above-stated components being equal to or more than 95 percent.

136. The optical glass of any of claims 133 to 135 wherein said optical glass comprises 0-25 molar percent (excluding 0 molar percent) of BaO.

137. An optical glass having the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $Nb_2O_5$ ,  $WO_3$ ,  $TiO_2$ , and  $K_2O$ , not comprising substantial amount of  $GeO_2$ , and comprising, as molar percentages, 15-30 percent of  $P_2O_5$ ; 0.5-15 percent of  $B_2O_3$ ; 5-25 percent of  $Nb_2O_5$ ; 0-40 percent (excluding 0 percent) of  $WO_3$ ; not more than 10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_2O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $K_2O$  is 1-15 percent); and 0-30 percent (excluding 0 percent and 30 percent) of at least one RO selected from among BaO, ZnO, and SrO.

138. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-40 molar percent of  $WO_3$ .

139. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-9 molar percent of  $TiO_2$ .

140. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 1-5 molar percent of  $K_2O$ .

141. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-40 molar percent of  $WO_3$ , 2-9 molar percent of  $TiO_2$ , and 1-5 molar percent of  $K_2O$ .

142. An optical glass comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 2-40 percent of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2 to 10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of  $Li_2O$ ;

2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent; a density of oxygen atoms contained is in the range of from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/\text{cm}^3$ , as well as not comprising substantial amount of GeO<sub>2</sub>.

143. An optical glass comprising, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub> (where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 2-40 percent of WO<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 2 to 10 percent of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 29-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent, as well as not comprising substantial amount of GeO<sub>2</sub>.

144. An optical glass comprising, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub> (where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 2-40 percent of WO<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 2 to 10 percent of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-11 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent, as well as not comprising substantial amount of GeO<sub>2</sub>.

145. An optical glass having the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $Nb_2O_5$ ,  $TiO_2$ ,  $BaO$ ,  $ZnO$ ,  $Li_2O$ ,  $Na_2O$  and  $K_2O$  or the composition comprising the above essential components and  $Sb_2O_3$ , and comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent (excluding 0 percent) of  $Nb_2O_5$ ; 0 to 10 percent (excluding 0 percent) of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent (excluding 0 percent) of  $BaO$ ; 0-20 percent (excluding 0 percent) of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent (excluding 0 percent) of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); and 0-1 percent of  $Sb_2O_3$ ; where a density of oxygen atoms contained is in the range of from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/cm^3$ .

146. An optical glass having the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $Nb_2O_5$ ,  $TiO_2$ ,  $BaO$ ,  $ZnO$ ,  $Li_2O$ ,  $Na_2O$  and  $K_2O$  or the composition comprising the above essential components and  $Sb_2O_3$ , and comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 2-40 percent of  $WO_3$ ; 0-25 percent (excluding 0 percent) of  $Nb_2O_5$ ; 0 to 10 percent (excluding 0 percent) of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent (excluding 0 percent) of  $BaO$ ; 0-20 percent (excluding 0 percent) of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent (excluding 0 percent) of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 29-45 percent); and 0-1 percent of  $Sb_2O_3$ .

147. An optical glass having the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $WO_3$ ,  $Nb_2O_5$ ,  $TiO_2$ ,  $BaO$ ,  $ZnO$ ,  $Li_2O$ ,  $Na_2O$  and  $K_2O$  or the composition comprising the above essential components and  $Sb_2O_3$ , and comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of

P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 2-40 percent of WO<sub>3</sub>; 0-25 percent (excluding 0 percent) of Nb<sub>2</sub>O<sub>5</sub>; 0 to 10 percent (excluding 0 percent) of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-11 percent (excluding 0 percent) of BaO; 0-20 percent (excluding 0 percent) of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 0-15 percent (excluding 0 percent) of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); and 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>.

148. The optical glass of claim 145 or 146 wherein said optical glass comprises 0-11 percent of BaO.

149. The optical glass of any of claims 142, 143, 145 and 1473 wherein said total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is equal to or more than 29 molar percent.

150. The optical glass of any of claims 143, 144, 146 and 147 wherein said optical glass has a density of oxygen atoms contained in the range of from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/\text{cm}^3$ .

151. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 2-9 molar percent of TiO<sub>2</sub>.

152. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 1-5 molar percent of K<sub>2</sub>O.

153. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 2-9 molar percent of TiO<sub>2</sub> and 1-5 molar percent of K<sub>2</sub>O.

154. An optical glass comprising P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, TiO<sub>2</sub>, and an alkali metal oxide and not comprising substantial amount of GeO<sub>2</sub>, wherein the total quantity of P<sub>2</sub>O<sub>5</sub> and

$B_2O_3$  is 15-35 molar percent and the content of  $WO_3$  is 2-45 molar percent, the content of  $TiO_2$  is 2-9 molar percent, the content of  $Li_2O$  is 2-30 molar percent, the content of  $K_2O$  is 1-5 molar percent; where a density of oxygen atoms contained ranges from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/cm^3$ .

155. The optical glass of any of claims 142 to 154 wherein said optical glass exhibits a glass transition temperature equal to or less than  $530^\circ C$  and/or a yield point temperature equal to or less than  $580^\circ C$ .

156. The optical glass of any of claims 142 to 155 wherein said optical glass exhibits a refractive index in the range of from 1.7 to 2.0, an Abbé number in the range of from 20 to 32.

157. The optical glass of any of claims 142 to 156 wherein said optical glass exhibits a liquid phase temperature equal to or less than  $970^\circ C$ .

158. A precision press molding glass preform being composed of the optical glass of any of claims 125 to 157.

159. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than  $0.4 \text{ Pa} \cdot \text{s}$ , wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$ ; 0-25 percent of  $Nb_2O_5$ ; 0-40 percent of  $WO_3$ ; 2-10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_{2}O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $Li_2O$  is 2-30 percent, the quantity of  $Na_2O$  is 2-30 percent, and the quantity of  $K_2O$  is 1-15 percent); and 0-30 percent

(excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

160. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, Li<sub>2</sub>O, Na<sub>2</sub>O and K<sub>2</sub>O and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'<sub>2</sub>O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O (where the quantity of Li<sub>2</sub>O is 2-30 percent, the quantity of Na<sub>2</sub>O is 2-30 percent, and the quantity of K<sub>2</sub>O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

161. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance  $\lambda 80$  is equal to or less than 500nm and a transmittance  $\lambda 5$  is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, Li<sub>2</sub>O, and Na<sub>2</sub>O, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 0-40 percent of WO<sub>3</sub>; 2-10 percent of TiO<sub>2</sub>; 4-45 percent of at least one R'<sub>2</sub>O selected from among Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O (where the quantity of Li<sub>2</sub>O is 2-30 percent, the quantity of Na<sub>2</sub>O is 2-30 percent, and the quantity of K<sub>2</sub>O is 0-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

162. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ , and  $Na_2O$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$ ; 0-25 percent of  $Nb_2O_5$ ; 0-40 percent of  $WO_3$ ; 2-10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_2O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $Li_2O$  is 2-30 percent, the quantity of  $Na_2O$  is 2-30 percent, and the quantity of  $K_2O$  is 0-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among  $BaO$ ,  $ZnO$ , and  $SrO$ ; with the total content of the above-stated components being equal to or more than 94 percent.

163. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ ,  $Na_2O$ , and  $K_2O$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$ ; 0-25 percent of  $Nb_2O_5$ ; 0-40 percent of  $WO_3$ ; 2-10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_2O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $Li_2O$  is 2-30 percent, the quantity of  $Na_2O$  is 2-30 percent, and the quantity of  $K_2O$  is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among  $BaO$ ,  $ZnO$ , and  $SrO$ ; with the total content of the above-stated components being equal to or more than 94 percent.

164. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher

than 0.4 Pa · s, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub> (where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 0-40 percent of WO<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 2-10 percent of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

165. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O, and comprises, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub> (where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 0-40 percent of WO<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 2-10 percent of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

166. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the

range of from 20 to 28.5, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ , and  $Na_2O$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2-10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

167. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ , and  $Na_2O$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2-10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 0-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

168. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance  $\lambda$  80 is equal to or less than 500nm and a transmittance  $\lambda$  5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $TiO_2$ ,  $Li_2O$ ,  $Na_2O$ , and  $K_2O$ , and comprises, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent (excluding 0 percent) of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2-10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 1-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

169. A precision press molding glass preform being composed of the optical glass having the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $Nb_2O_5$ ,  $TiO_2$ ,  $Li_2O$ ,  $Na_2O$ , and  $K_2O$ , and comprising, as molar percentages, 15-30 percent of  $P_2O_5$ ; 0.5-15 percent of  $B_2O_3$ ; 5-25 percent of  $Nb_2O_5$ ; 0-40 percent of  $WO_3$ ; 2-10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_2O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $Li_2O$  is 2-30 percent, the quantity of  $Na_2O$  is 2-30 percent, and the quantity of  $K_2O$  is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among  $BaO$ ,  $ZnO$ , and  $SrO$ ; with the total content of the above-stated components being equal to or more than 95 percent.

170. The precision press molding glass preform of claim 169 wherein said optical glass comprises 0-25 molar percent (excluding 0 molar percent) of  $BaO$ .

171. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.80 to 2.0 and an Abbé number in the range of from 20 to 32, wherein said optical glass has the composition comprising, as essential components,  $P_2O_5$ ,  $B_2O_3$ ,  $Nb_2O_5$ ,  $WO_3$ ,  $TiO_2$ ,  $Li_2O$ ,  $Na_2O$ , and  $K_2O$ , and comprises, as molar percentages, 15-30 percent of  $P_2O_5$ ; 0.5-15 percent of  $B_2O_3$ ; 5-25 percent of  $Nb_2O_5$ ; 0-40 percent (excluding 0 percent) of  $WO_3$ ; not more than 10 percent of  $TiO_2$ ; 4-45 percent of at least one  $R'_2O$  selected from among  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  (where the quantity of  $Li_2O$  is 2-30 percent, the quantity of  $Na_2O$  is 2-30 percent, and the quantity of  $K_2O$  is 1-15 percent); and 0-30 percent (excluding 0 percent and 30 percent) of at least one RO selected from among  $BaO$ ,  $ZnO$ , and  $SrO$ .

172. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 0-40 percent of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2-10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 1-15 percent of  $K_2O$  (where the total quantity of  $Li_2O$ ,  $Na_2O$ , and  $K_2O$  is 10-45 percent); 0-10 percent of  $CaO$ ; 0-10 percent of  $SrO$ ; 0-5 percent of  $Al_2O_3$ ; 0-5 percent of  $Y_2O_3$ ; 0-1 percent of  $Sb_2O_3$ ; and 0-1 percent of  $As_2O_3$ ; where the total quantity of all of the above-listed components is equal to or more than 94 percent; a density of oxygen atoms contained is in the range of from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/cm^3$ .

173. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of  $P_2O_5$ ; 0.2-15 percent of  $B_2O_3$  (where the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 percent); 2-40 percent of  $WO_3$ ; 0-25 percent of  $Nb_2O_5$ ; 2-10 percent of  $TiO_2$  (where the total quantity of  $WO_3$ ,  $Nb_2O_5$ , and  $TiO_2$  is 20-45 percent); 0-25 percent of  $BaO$ ; 0-20 percent of  $ZnO$  (where the total quantity of  $BaO$  and  $ZnO$  is less than 30 percent); 2-30 percent of  $Li_2O$ ; 2-30 percent of  $Na_2O$ ; 1-15

percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 29-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

174. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of P<sub>2</sub>O<sub>5</sub>; 0.2-15 percent of B<sub>2</sub>O<sub>3</sub> (where the total quantity of P<sub>2</sub>O<sub>5</sub> and B<sub>2</sub>O<sub>3</sub> is 15-35 percent); 2-40 percent of WO<sub>3</sub>; 0-25 percent of Nb<sub>2</sub>O<sub>5</sub>; 2-10 percent of TiO<sub>2</sub> (where the total quantity of WO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, and TiO<sub>2</sub> is 20-45 percent); 0-11 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li<sub>2</sub>O; 2-30 percent of Na<sub>2</sub>O; 1-15 percent of K<sub>2</sub>O (where the total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al<sub>2</sub>O<sub>3</sub>; 0-5 percent of Y<sub>2</sub>O<sub>3</sub>; 0-1 percent of Sb<sub>2</sub>O<sub>3</sub>; and 0-1 percent of As<sub>2</sub>O<sub>3</sub>; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

175. The precision press molding glass preform of claim 172 or 173 wherein said optical glass comprises 0-11 molar percent of BaO.

176. The precision press molding glass preform of claim 172 or 174 wherein said total quantity of Li<sub>2</sub>O, Na<sub>2</sub>O, and K<sub>2</sub>O is equal to or more than 29 percent.

177. The precision press molding glass preform of claim 173 or 174 wherein said optical glass has a density of oxygen atoms contained in the range of from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/\text{cm}^3$ .

178. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.80 to 2.0 and an Abbé number in the range of from 20 to 32, and comprising P<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub>, WO<sub>3</sub>, TiO<sub>2</sub>, and an alkali metal oxide,

wherein the total quantity of  $P_2O_5$  and  $B_2O_3$  is 15-35 molar percent, the content of  $WO_3$  is 2-45 molar percent, the content of  $TiO_2$  is 2-9 molar percent, the content of  $Li_2O$  is 2-30 molar percent, the content of  $K_2O$  is 1-5 molar percent, and a density of oxygen atoms contained ranges from  $4.2 \times 10^{22}$  to  $5.2 \times 10^{22}/cm^3$ .

179. The precision press molding glass preform of any of claims 172 to 178 wherein said optical glass exhibits a glass transition temperature equal to or less than  $530^\circ C$  and/or a yield point temperature equal to or less than  $580^\circ C$ .

180. The precision press molding glass preform of any of claims 172 to 177 wherein said optical glass exhibits a refractive index in the range of from 1.7 to 2.0, and an Abbé number in the range of from 20 to 32.

181. The precision press molding glass preform of any of claims 172 to 177 wherein said optical glass exhibits a refractive index in the range of from 1.80 to 2.0, and an Abbé number in the range of from 20 to 32.

182. The precision press molding glass preform of any of claims 172 to 181 wherein said optical glass exhibits a liquid phase temperature equal to or less than  $970^\circ C$ .

183. An optical part being composed of the optical glass of any of claims 125 to 157.

184. An optical part prepared by precisely press molding the precision press molding glass of any of claims 158 to 182.

Support claims 125 to 184 are shown in the table below:

	Base claim	Additional features
125	Claim 4	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
126	Claim 5	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
127	Claim 6	[0046] on page 19, [0024] on page 13, [0029] on page 16
128	Claim 6	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16
129	Claim 6	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
130	Claim 7	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
131	Claim 8	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
132	Claim 9	[0046] on page 19, [0024] on page 13, [0029] on page 16
133	Claim 9	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16
134	Claim 9	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
135	Claims 10 and 11	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
136	Claim 12	
137	Claim 13	[0046] on page 19, [0024] on page 13, [0027] on page 14
138		[0060] on page 23
139		[0029] on page 16
140		[0027] on page 14

141		[0060] on page 23, [0029] on page 16, [0027] on page 14
142	Claim 14	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
143	Claim 15	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
144	Claim 16	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
145	Claim 17	[0060] on page 23
146	Claim 18	[0062] on page 23
147	Claim 19	[0062] on page 23
148	Claim 20	
149	Claim 21	
150	Claims 22 -24	
151		[0029] on page 16
152		[0027] on page 14
153		[0029] on page 16, [0027] on page 14
154	Claim 23	[0046] on page 19, [0029] on page 16, [0027] on page 14
155	Claim 29	
156	Claims 30-33	
157	Claim 34	
158		Precision press molding glass preform of claims 125-157
159		Precision press molding glass preform of claim 125 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, WO <sub>3</sub> is an optional component, and GeO <sub>2</sub> is not mentioned.
160		Precision press molding glass preform of claim 126 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, WO <sub>3</sub> is an optional

		component, and GeO <sub>2</sub> is not mentioned.
161		Precision press molding glass preform of claim 127 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, WO <sub>3</sub> is an optional component, and GeO <sub>2</sub> is not mentioned.
162		In claim 161, a liquid phase temperature is further defined.
163		Based on [0027] on page 14, the content of K <sub>2</sub> O is defined as 1-15 percent in claim 161.
164		Precision press molding glass preform of claim 130 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, WO <sub>3</sub> is an optional component, and GeO <sub>2</sub> is not mentioned.
165		Precision press molding glass preform of claim 131 wherein WO <sub>3</sub> is an optional component and GeO <sub>2</sub> is not mentioned.
166		Precision press molding glass preform of claim 132 wherein WO <sub>3</sub> is an optional component, and GeO <sub>2</sub> is not mentioned.
167		In claim 166, a liquid phase temperature is further defined.
168		Based on [0027] on page 14, the content of K <sub>2</sub> O is defined as 1-15 percent in claim 167.
169		Precision press molding glass preform of claim 135 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, WO <sub>3</sub> is an optional component, and GeO <sub>2</sub> is not mentioned.
170		Originally filed claim 12
171		Precision press molding glass preform of claim 137 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, and GeO <sub>2</sub> is not mentioned. Based on [0017] on page 11 and originally filed claims 30 to 33, a refractive index and an Abbé number are further defined.
172		Precision press molding glass preform of claim 142 wherein GeO <sub>2</sub> is not mentioned.

173		Precision press molding glass preform of claim 143 wherein Li <sub>2</sub> O and Na <sub>2</sub> O are essential components, and GeO <sub>2</sub> is not mentioned.
174		Precision press molding glass preform of claim 144 wherein GeO <sub>2</sub> is not mentioned.
175		Originally filed claim 20
176		Originally filed claim 21
177		Originally filed claims 22 to 24
178		Precision press molding glass preform of claim 154 wherein GeO <sub>2</sub> is not mentioned. Based on [0017] on page 11 and originally filed claims 30 to 33, a refractive index and an Abbé number are further defined.
179		Originally filed claim 29
180		Originally filed claims 30-33
181		[0017] on page 11, Originally filed claims 30-33
182		Originally filed claim 34
183		Optical part of claims 125-157
184		Optical part prepared by precisely press molding the precision press molding glass of any of claims 158 to 182.